Sources and pathways of freshwater in the East Greenland Current, 2002

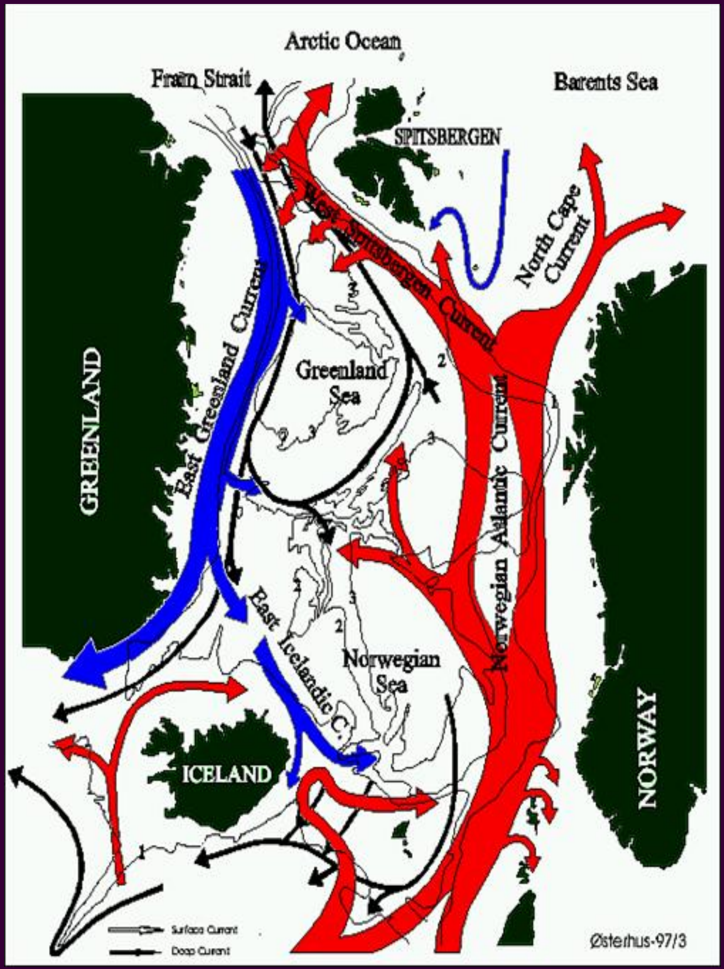
Abigail Mauldin, Peter Schlosser,
Robert Newton, Richard Mortlock
Lamont-Doherty Earth Observatory

Outline

1. Background
2. Data
   - $\delta^{18}O$
   - Tritium (^3H)
3. Mass fractions
   - Method
   - Results
4. Conclusions

EGC: background

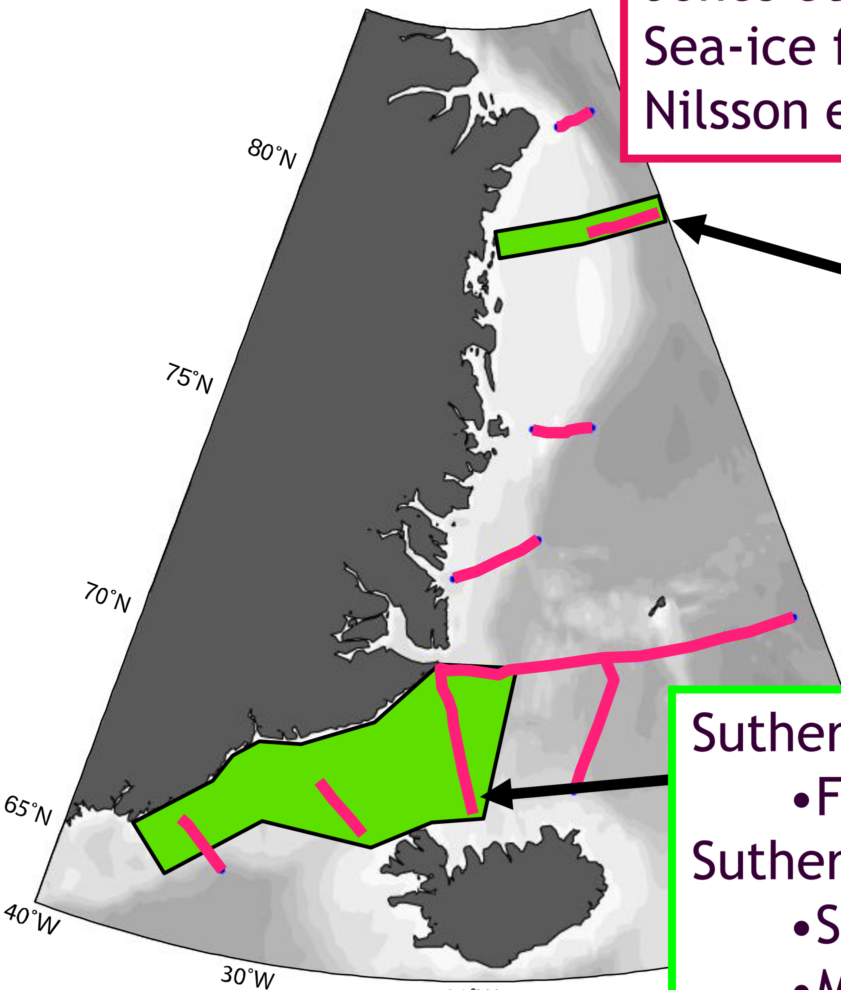
- The East Greenland Current (EGC) transports cold, fresh water and sea-ice southward out of the Arctic
- Liquid FW flux ~80 mSv
  - Rabe et al. (2009) Nilsson et al. (2008)
- Sea-ice flux ~80 mSv
  - FW_T Fram Strait 162 mSv
    Canadian Arch 100 mSv
  - Dickson et al. (2007)



FW exported through Fram and Davis Straits controls buoyancy in the Nordic and Labrador Seas, affecting the MOC. Also essential part of the sea-ice budget.

This study: sampling in 2002 May (Swedish IB Oden) & June (R/V Knorr)

Jones et al. (2008): MW ≤ 12% PW ≤ 4%
Sea-ice formation: ≤ 5% ; SIM ≤ 1%
Nilsson et al. (2008): FW transport < 78 Sv vs S=35



Rabe et al. (2009):

- Sampling - late summer
- 1998, 2004, 2005
- FW transport: 80 mSv vs S=34.92
- MW ≤ 15%
- Sea-ice formation: ≤ 8%

Sutherland and Pickart (2008):

- FW transport 56 - 96 mSv vs S=34.8

Sutherland et al. (2009):

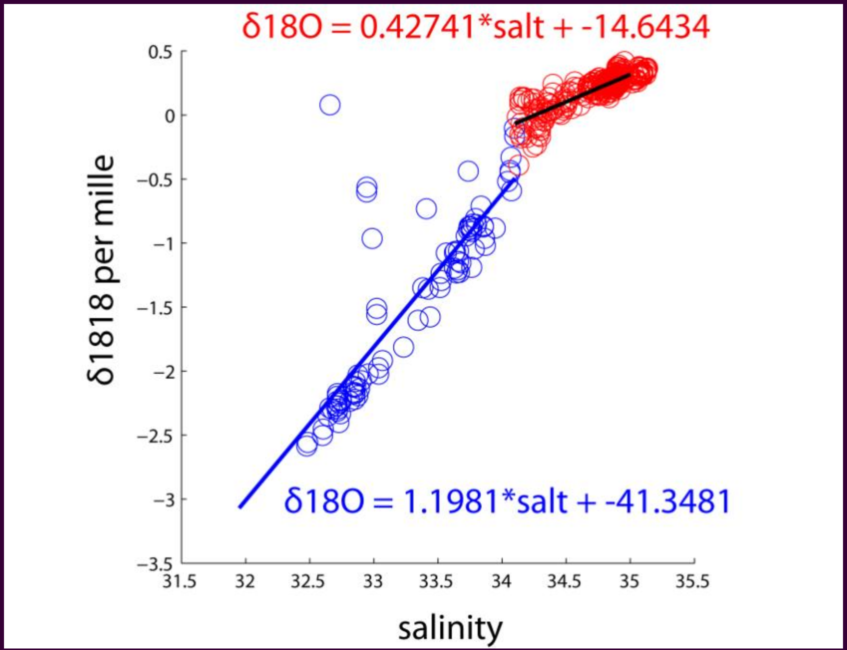
- Sampling July/Aug 2004
- MW ≤ 12% PW ≤ 40%
- Sea-ice formation ≤ 6% ; SIM ≤ 15% melt

Cruise data

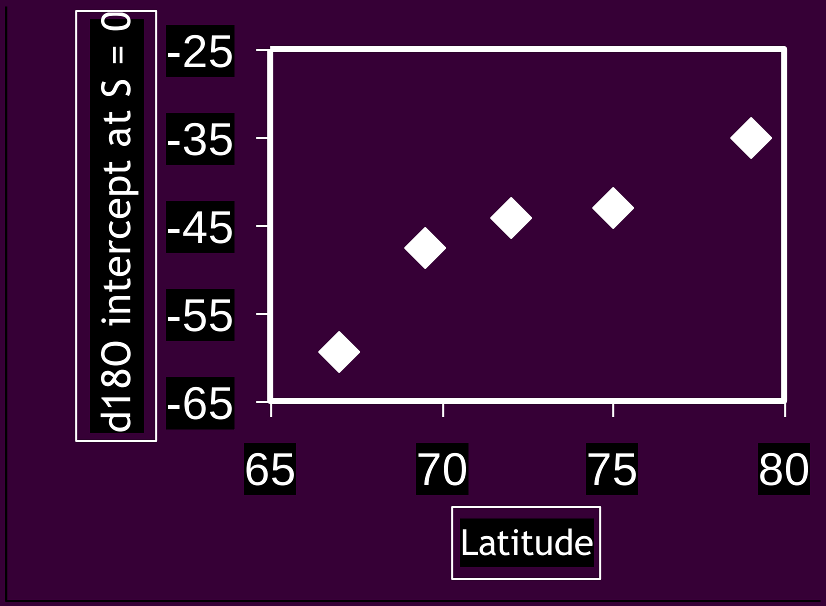
- For mass separation:
  - Salinity
  - Oxygen isotopes: H218O/H216O vs std : $\delta^{18}O$ per mille
    - Meteoric water is *LIGHTEST ENDMEMBER*
  - Nutrients: NO3, PO4
    - P* = PO4 - (1/16)*NO3
    - Pacific water has high P* (excess phosphate) vs Atlantic water
  - Alkalinity
    - rivers (1130 µmol/l) > sea-ice (175 µmol/l) > precipitation
- Transient tracer data
  - ^{3}H (tritium, TU): high in Arctic river water

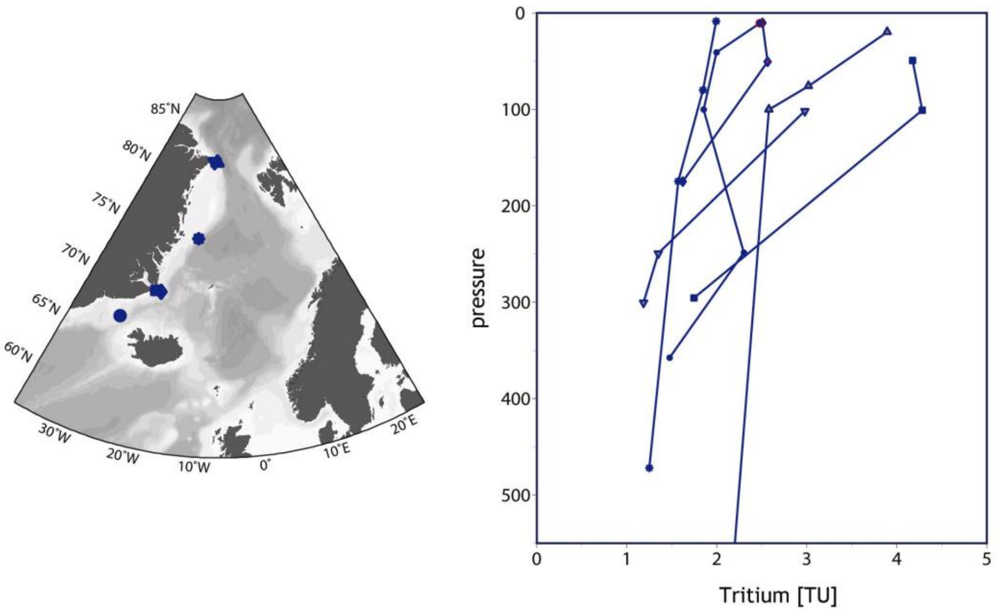
δ18O vs salinity

All sections except 81N



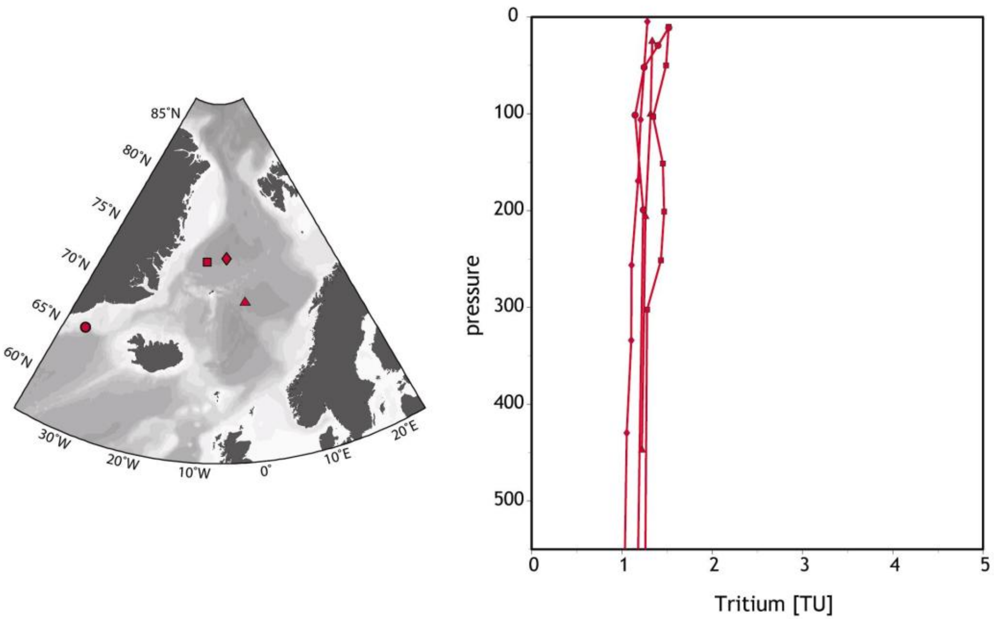
Intercept of regression for S>34.1=-41‰ explained by formation of sea ice





Elevated ^{3}H in surface water:

Arctic river signature

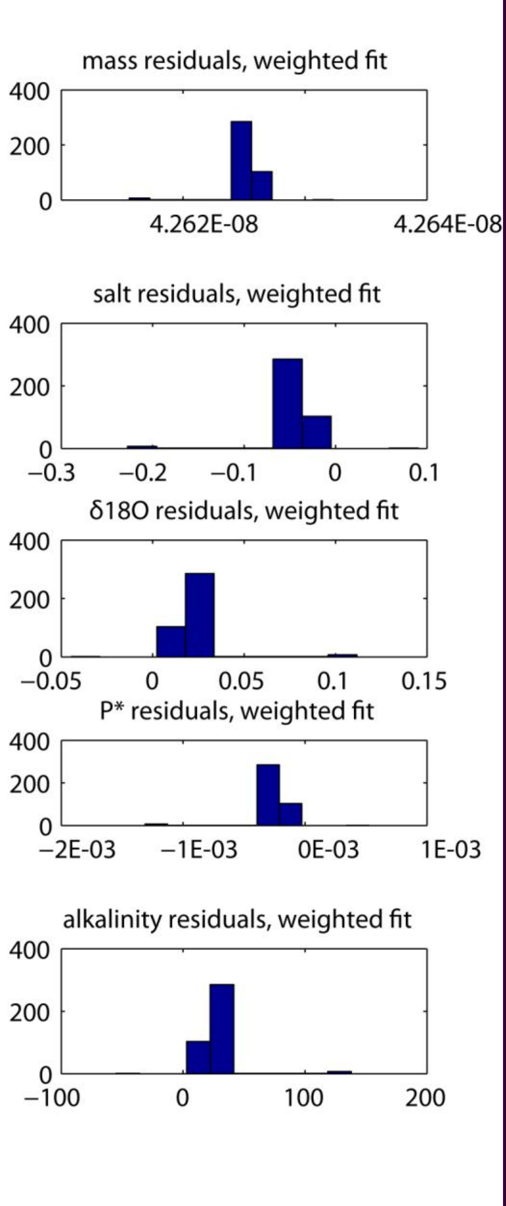


Mass separation

- Weighted least-squares solution for 4 fractions:
  - Atlantic water, Pacific water, meteoric water and sea-ice melt
- 5 equations: balances of mass, salinity, $\delta^{18}O$, P* and alkalinity
  - Solution = inv(A'xweights'xweightsxA)xA'xweights'xweightsxdata
- weights reflect uncertainty in end-member values

	salinity	$\delta^{18}O$ per mille	P* µmol/l	Alk_T µmol/l
Atlantic water	34.92 ± 0.80	0.3 ± 0.1	0.07 ± 0.10	2329 ± 200
Pacific water (Chukchi slope)	32.70 ± 0.50	-1.1 ± 1.0	0.82 ± 0.10	2235 ± 200
Meteoric water	0 ± 0.001	-20 ± 2	0.07 Er: 0.4	690 ± 400
Sea-ice melt	2.5 ± 2.0	1 ± 2	0.07 Er: 0.4	175 ± 200
Samples	31.95 to 35.14	-2.85 to 0.42	0 to 0.65	2209 to 2326

Mass separation weights and residuals



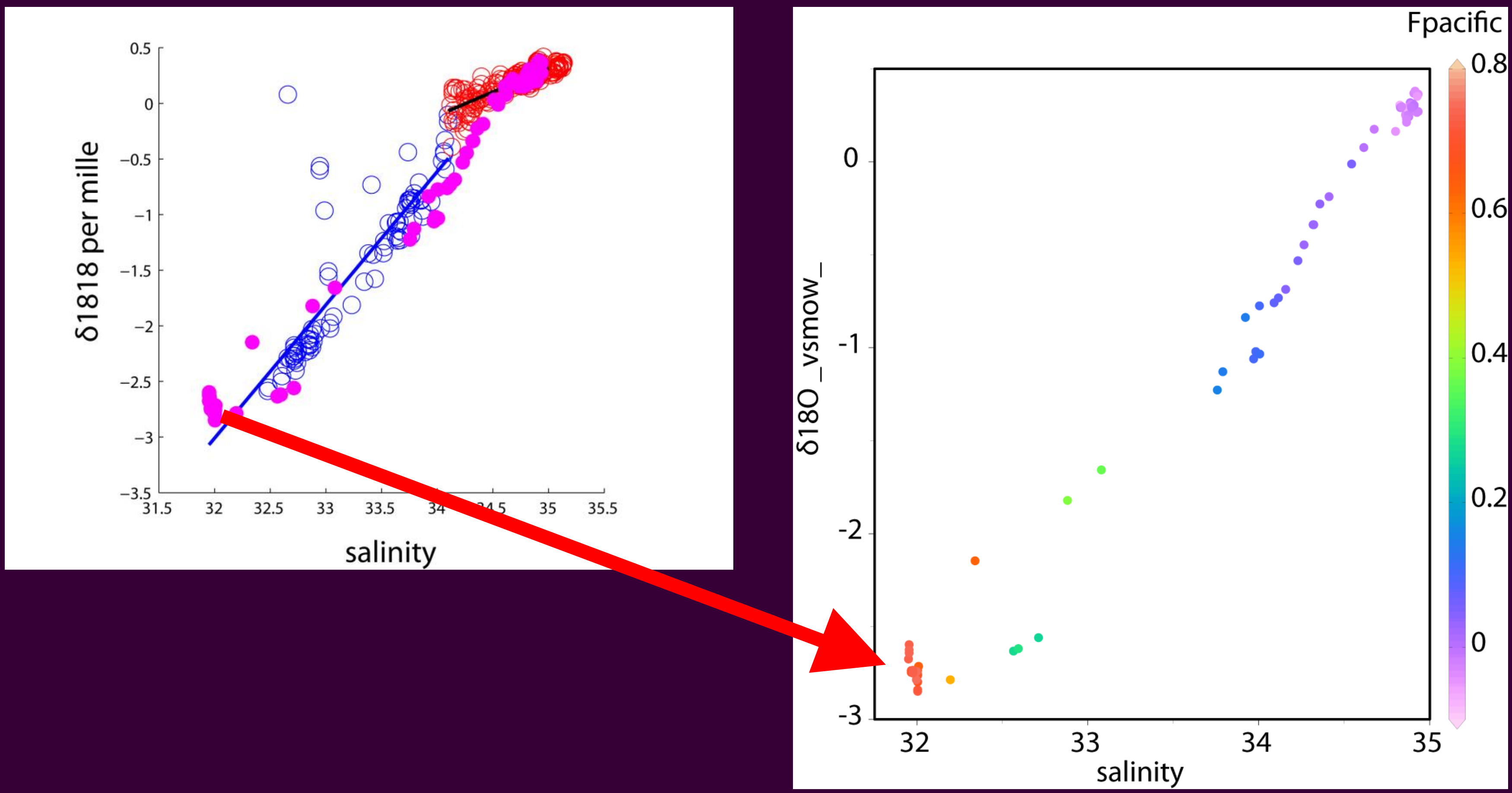
- Method similar to OMP but without non-negativity constraint
- Mass is weighed very heavily
  - very small mass residual
- Other parameters weighed by maximum error

δ18O vs salinity

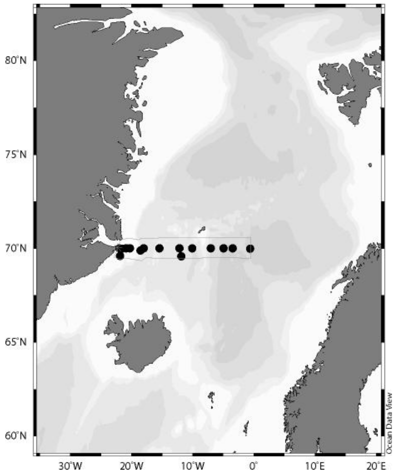
All sections

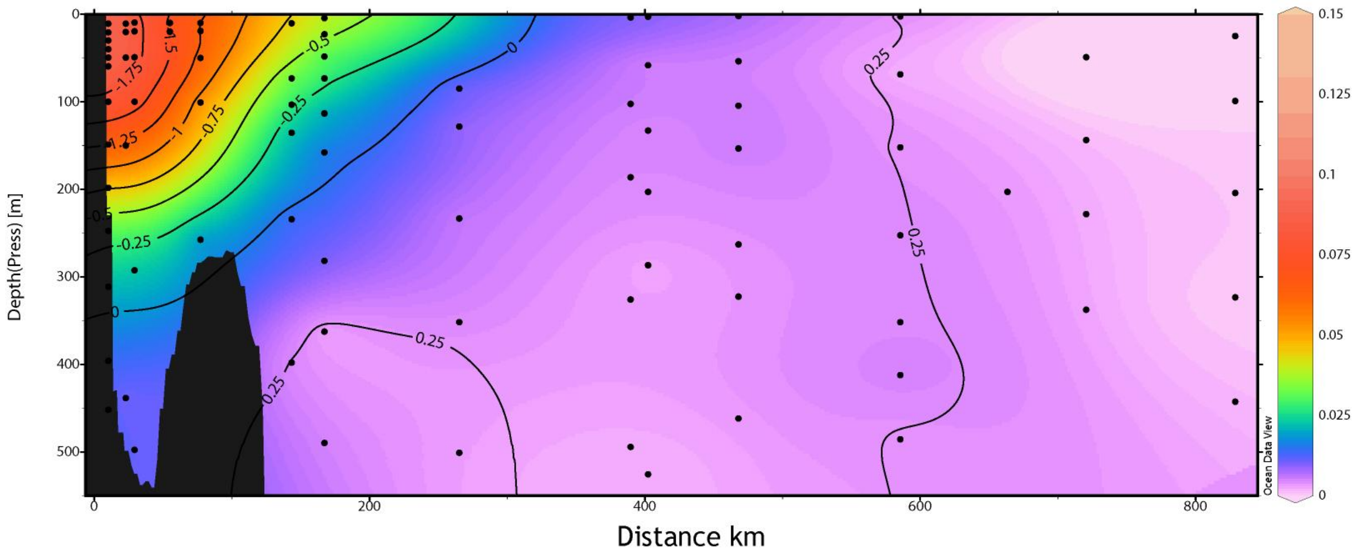
81N samples off main trend:

highest Pacific fraction

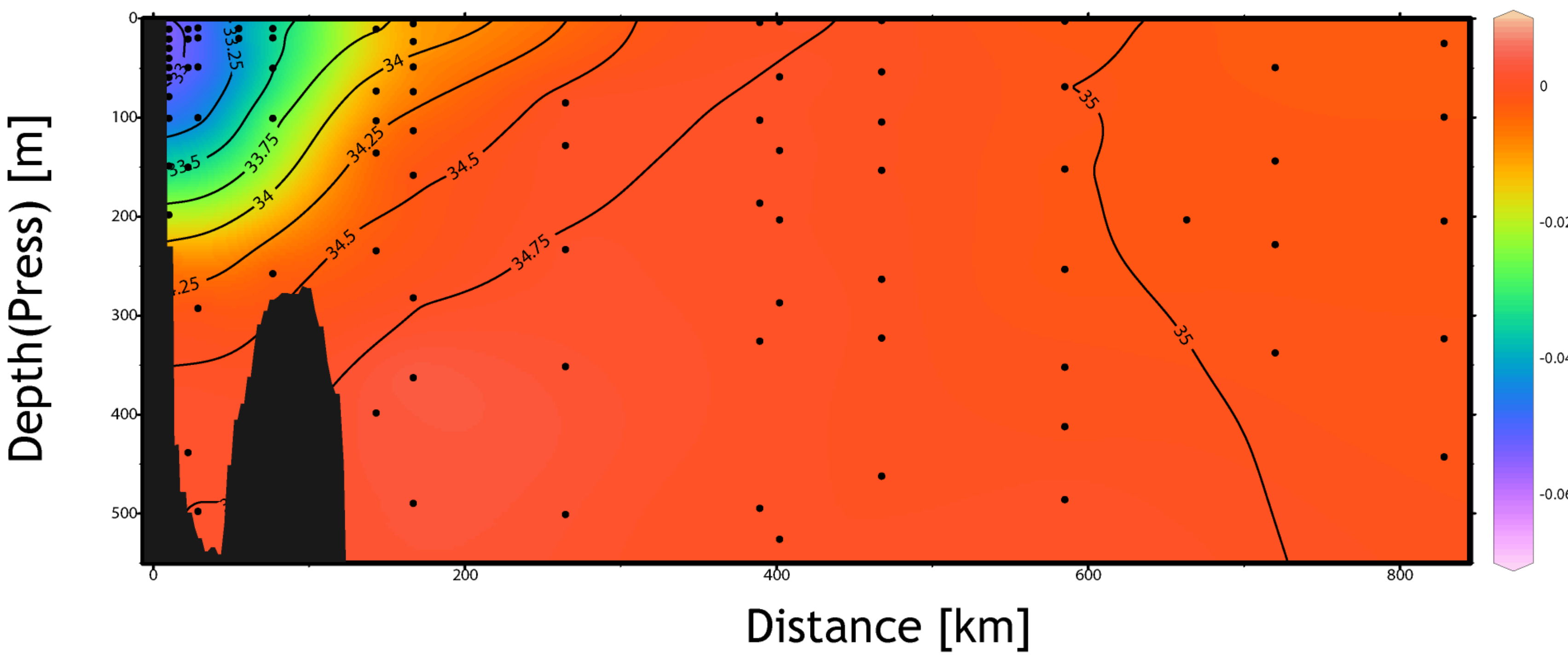


Mass fraction section at 70N:
River water fraction = 0-10%

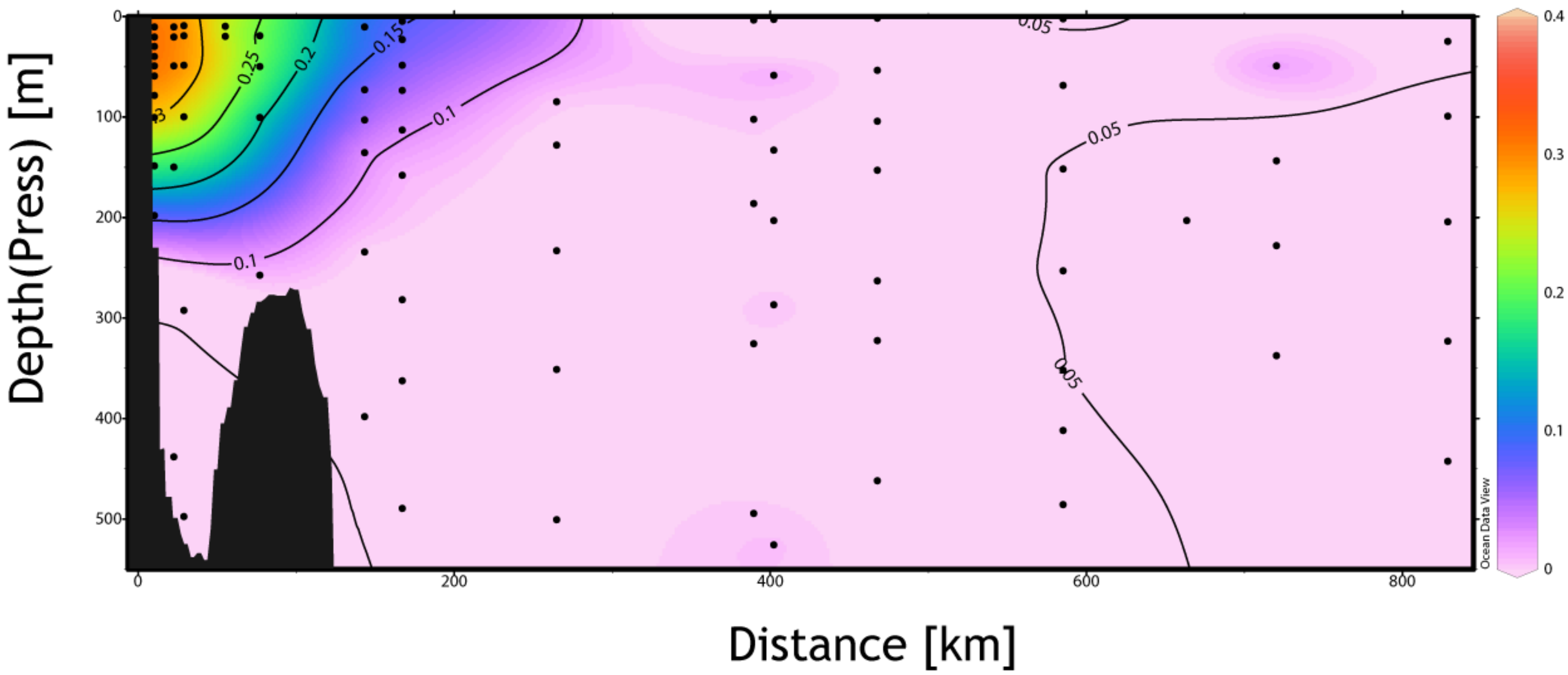




Mass fraction section at 70N:
Up to 6% sea ice removal
Up to 0.7% sea ice melt added



Mass fraction section at 70N:
Pacific water fraction = 0-36%

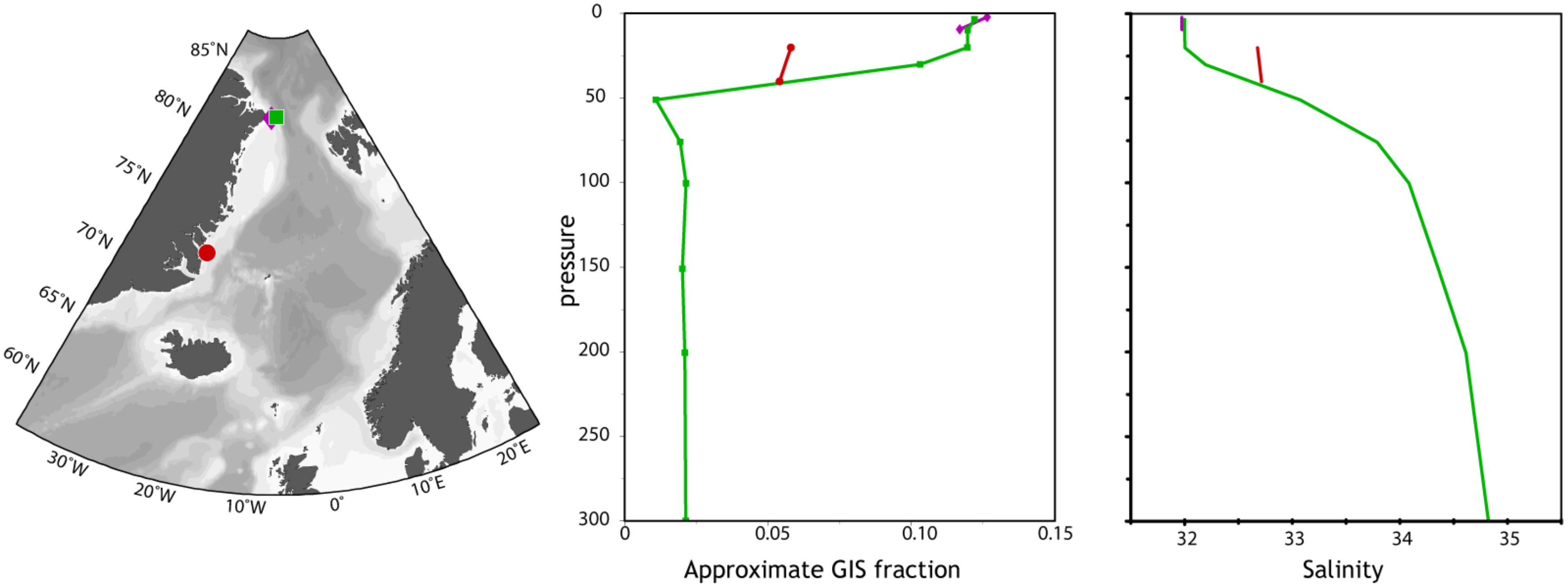


Greenland ice sheet melt water as an endmember?

- δ18O ~ 37.5‰ : lowest endmember
- alkalinity ~ 10µmol/l : lowest endmember
  - salinity = 0; P* = 0
- Mass separation results:
  - Greater errors than weighted fit
    - artifact: negative fractions
  - GIS fraction > bgd value for a few shelf stations

Five component mass fraction analysis:

- Three stations have GIS fraction above background



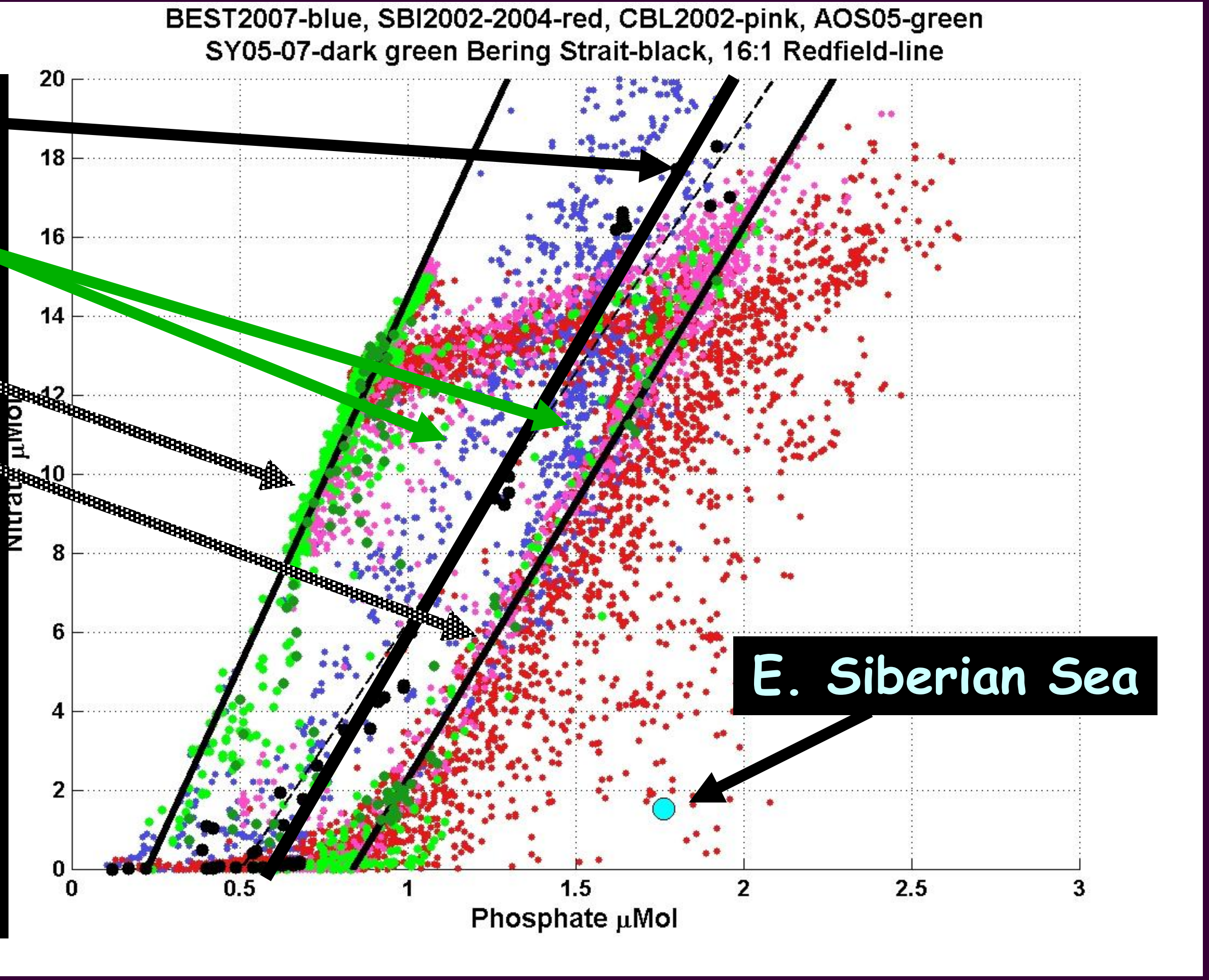
Conclusions

- Weighted LSQ method works well in EGC
- Evidence of GIS water in a few shelf stations

Nutrients in Pacific water and arctic shelves:

Bering Strait Inflow: reasonable average of shallow Bering Sea, and intermediate between Atlantic and Pacific N/P relationships.

Transformation from BSI to the "Pacific" end member requires denitrification and/or phosphate addition in the Chukchi Sea.



E. Siberian Sea

Can Chukchi slope water be assumed to be transformed Bering Strait Inflow?

- Multiple inversions with a mixtures of “aged” Pacific water (1 mg-at/m^2d denitrification rate) and E. Siberian shelf water, and cost function based on:
  - Sum of fractions = 1
  - Non-negative water masses
  - Matching age tracers
- Best estimate was 85/15: Pacific/Shelf
- But cost function minimum was weak.
- Error sources: PO* estimate for Pacific/shelf end-members, age constraint, and denitrification rates.